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Early morning training impacts previous night's sleep in NCAA Division I cross country runners

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Abstract:

The effects of training time on sleep has been previously studied; however, the influence on sleep in female collegiate cross-country runners is unknown. The aim of this study was to investigate the influence of training time on self-reported sleep metrics. Eleven female collegiate cross-country runners (mean [*M*] age = 19 years, standard deviation [*SD*] age = 1 year; *M* [*SD*] body mass = 58.8 [9.6] kg; *M* [*SD*] height = 168.4 [7.7] cm; *M* [*SD*] VO_{2max} = 53.6 [5.6] mL·kg^{-1}·min^{-1}) competing in the 2016 NCAA cross-country season were included in this study. Participants completed a sleep diary daily to assess perceived measures of sleep on days when training took place between the hours of 5:00–8:00 a.m. (AM), and when training did not take place during this time (NAM). Sleep quality questions utilized a 5-point Likert scale, in which a score of 1 is associated with the worst outcomes and a score of 5 is associated with the best outcomes. Sleep duration was significantly higher on NAM (*M* [*SD*] = 8.26 [1.43] h) compared to AM (*M* [*SD*] = 7.97 [1.09] h, $p < .001$). Sleep quality was significantly higher on NAM (*M* [*SD*] = 3.30 [1.01]) compared to AM (*M* [*SD*] = 3.02 [1.06], $p < .001$). The impairment of sleep quantity and quality the night prior to early morning training suggests that future considerations should be made to sleep schedules and/or training times to optimize perceived sleep quality.

Keywords: athlete wellness | collegiate athletes | sleep assessment | training schedule

Article:

Collegiate athletes represent a unique subset of the larger athletics population as they must balance the demands of their sport (i.e., training and competition), demands of being students with the associated high academic workloads, and the social aspect of being 18- to 22-year-old collegiate student athletes. Oftentimes, factors related to health and recovery, such as proper nutrition and sleep, are sacrificed to maintain balance of the aforementioned aspects of a student athlete's life. Athletes and coaches have reported that sleep is important to optimize performance (Venter, 2014); however, due to competing athletic and academic schedules, student athletes are often expected to train early in the morning, which may impact sleep behaviors (Venter, 2014). Sleep quantity, quality, structure, and consistency are recognized as important aspects of sleep behavior and have implications for health, well-being, and performance of competitive athletes (Leeder, Glaister, Pizzoferro, Dawson, & Pedlar, 2012; Schaal et al., 2015, 2011).

It has been suggested that young adults (ages 18–25) should obtain 7 to 9 hours of sleep every night (Hirshkowitz et al., 2015) to maintain healthy daily function with some stating that elite athletes may need even more for recovery (Calder, 2003). Despite these recommendations, prior research found that athletes obtained sub-optimal sleep quantity, especially on nights prior to training days. Elite swimmers slept, on average, 5.4 hours prior to training (Sargent, Halson, & Roach, 2014) and seventy athletes from seven different sports slept an average of 6.5 hours prior to training (Sargent, Lastella, Halson, & Roach, 2014). Other factors such as competition schedule congestion (Richmond et al., 2007), anxiety leading up to competition (Juliff, Halson, & Peiffer, 2015), and participating in competition have been shown to reduce sleep quality (Shearer, Jones, Kilduff, & Cook, 2015). Reduction in sleep quantity (less than 7 hours) has specific implications; this includes day time fatigue (Sateia, 2014), loss of vigour (Goel, Rao, Durmer, & Dinges, 2009), and increased feelings of sleepiness (Van Dongen, Maislin, Mullington, & Dinges, 2003).

Moreover, chronic sleep restriction (6 hours or less per night for 14 consecutive days) has been shown to produce similar cognitive impairments to that of two nights of total sleep deprivation (Van Dongen et al., 2003). Another concern surrounding this topic is that chronic sleep deprivation has been associated with lower perceived sleepiness when compared to a total sleep restriction group, indicating that chronically sleep deprived individuals may be unaware of their decrements (Van Dongen et al., 2003). This finding has specific implications for the student athlete population, considering many student athletes do not obtain the recommended amount of sleep and might not be aware of their need for more sleep (Mah, Kezirian, Marcello, & Dement, 2018).

Similar to the quantity of sleep obtained, sleep quality is of interest in the elite athlete population for its potential recovery and performance benefits (Mah et al., 2018). Sleep quality is a subjective measure that describes sleep disturbances and the experience related to awakening (American Psychiatric Association, 2013). This subjective measure of sleep quality has a strong positive correlation with slow-wave sleep (Åkerstedt, Hume, Minors, & Waterhouse, 1994), which is the stage of sleep in which growth hormone and other anabolic hormones that are vital for recovery are released (Sassin et al., 1969; Weitzman, 1976). Previous literature has pointed to the relationship of elite sport and sleep quality (Gupta, Morgan, & Gilchrist, 2017), indicating that travel (Richmond et al., 2007), training schedule (Juliff et al., 2015), competition (Juliff et al., 2015), and sport type led to a decrement in sleep quality. A lab-based study of recreationally active males demonstrated that poor sleep quality, assessed by the Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), was associated with poor physical performance outcomes, including lower maximum wattage, lower maximal oxygen consumption values, and higher heart rate max in a single maximal incremental cycling test (Antunes et al., 2017). In a study of elite team and individual athletes from 12 different sports, poor perceived sleep quality, assessed by a subjective survey, was associated with more losses than athletes with high perceived sleep quality (Brandt, Bevilacqua, & Andrade, 2017).

While sleep quantity and quality are relevant for all athletes, there are known differences in sleep characteristics between males and females that could potentially impact health and performance outcomes. Females have longer sleep latency and higher reports of sleepiness than males when under the age of 55 years old (Ohayon, Reynolds, & Dauvilliers, 2013). Females also have a 40% higher chance to experience insomnia than men (Zhang & Wing, 2006). In a sample of collegiate athletes of a variety of individual and team sports, females reported better sleep quality than males; however, 13% of females in this study had “fairly bad” or “very bad” sleep quality as rated by the Pittsburgh Sleep Quality Index (Mah et al., 2018).

In addition to these known sex differences, early morning training sessions negatively impacted sleep characteristics in a variety of professional sports when compared to rest days (Sargent, Lastella, et al., 2014). To date, no literature exists that has examined National Collegiate Athletic Association (NCAA) Division 1 (DI) female cross-country runner’s sleep characteristics throughout an entire competitive season. Understanding sleep characteristics of this cohort is of particular interest because, unlike professional athletes, these individuals have academic demands and other outside sources of stress, such as moving away from home, that might affect their sleep quantity, quality, and consistency. Understanding how early morning training sessions impact sleep quantity, quality, and structure in this population over an entire competitive season can provide valuable information for coaches, athletes, and strength and conditioning and medical personnel. Therefore, the aim of this study was to investigate the influence of training time on self-reported sleep metrics in collegiate female cross-country athletes. We hypothesized that sleep characteristics, specifically sleep duration and aspects of self-reported sleep quality, would be compromised on nights prior to early morning training. Sleep variables were collected and assessed over several months to determine if there were differences based on training start time.

Methods

Participants

This study utilized a criterion sampling approach (Patton, 2014). To be considered for inclusion in this study, subjects had to be part of the university’s women’s cross-country team. Following a descriptive meeting of the study’s protocols, benefits, and risks, individuals who were interested in participating provided written informed consent. Following medical clearance, 11 NCAA Division I female collegiate cross-country runners (mean [*M*] age = 19 years, standard deviation [*SD*] age = 1 year; *M* [*SD*] body mass = 58.8 [9.6] kg; *M* [*SD*] height = 168.4 [7.7] cm; *M* [*SD*] VO_{2max} = 53.6 [5.6] $mL \cdot kg^{-1} \cdot min^{-1}$) participated in this study, which took place during the 2016 NCAA cross-country season (August–December) in the Northeastern United States. The study’s procedures were approved by the Institutional Review Board at the University of Connecticut in the spirit of the Helsinki Declaration.

Procedures

In this observational study, sleep information was assessed daily via a validated self-reported sleep diary, the Karolinska Sleep Diary (KSD) (Åkerstedt et al., 1994). This survey has been validated with polysomnography and has strong correlations with multiple aspects of sleep

(0.46–0.66). The KSD is an 11 item questionnaire used to evaluate several facets of sleep, sleep duration, and aspects of perceived quality, such as ease of falling asleep, overall perception of sleep quality, sleep disturbances, sleep calmness, feeling of rest, and ease of wakening (Åkerstedt et al., 1994). The questions associated with sleep quality were presented on a 5-point Likert scale. For all questions on this scale, a score of "1" was associated with negative sleep measures and "5" was associated with positive sleep measures. For example, for the question, "How did you sleep?", participants could select a score of "1, Very Poorly" through "5, Very Well". To access the full survey and anchors, see Appendix. The KSD was distributed via email every day throughout the study (Qualtrics, June–December 2017, Provo, UT). The questionnaire was sent to the athlete's university-registered email initially at 6:00 a.m. and a reminder email was sent at 5:00 p.m. if the questionnaire was not completed by this time. The athletes were encouraged to complete the questionnaire upon waking and were given the opportunity to answer anytime that day. The survey took approximately three minutes to complete. The survey was completed in the morning by 54.8% of all respondents. Metrics derived from this questionnaire included Sleep duration, Sleep Latency, Sleep Quality, Refreshness, Dreams, Wake Episodes, Ease of Falling Asleep, and Ease of Awakening.

All sleep data from the entirety of the competitive season were placed in two conditions that were differentiated by nights of sleep prior to a training start time of morning (AM), defined as training starting between the hours of 5:00 a.m. to 8:00 a.m., and non-morning (NAM), which was defined as every night of sleep not included in the AM condition (including days of afternoon training, races, and rest). These conditions were derived retrospectively by filtering data obtained from a heart rate and global positioning system device (Polar Electro M400, Kempele, Finland) in which players were instructed to log all coach-initiated team activity throughout the competitive season.

Data Analyses

A power analysis was completed post-hoc for one of the variables of interest, sleep quality, for a within-subjects research design using the effect size with alpha error probability = 0.05. Any day that an athlete did not complete a sleep survey was considered missing and was excluded from the analysis. All missing survey data were considered missing completely at random. After all missing data were removed, the total number of observations and the number of athletes included in each night type were recorded (AM: 165 observations, 11 athletes; NAM: 380 observations, 11 athletes). To account for the violation of independence, unequal group sizes, missing data, and variations between each athlete, a linear mixed effect model was used. To determine the effects of early morning training on sleep quality measurements, a linear mixed model was used, with AM and NAM groups as fixed factors and individual athlete as a random factor. Data are reported as M (SD) and M difference (MD) with 95% confidence intervals (CI) to depict changes between AM and NAM conditions. Significance was set *a priori* at $\alpha < 0.05$. Effect sizes (ES) were calculated using the Hedges' g method to account for the unequal sample sizes between AM and NAM. ES was interpreted according to the following thresholds from previous research: <0.2 trivial, 0.2–0.6 = small, 0.7–1.1 = moderate, 1.2–2.0 = large, and >2.0 = very large (Batterham & Hopkins, 2006). To make meaningful deductions regarding the effect of early morning training on sleep in relation to the smallest important difference, magnitude analysis, as described by Batterham and Hopkins (2006), was utilized. Differences were considered practically important and substantial when there was >75% likelihood of exceeding the smallest important ES value (0.2) and classifications were set at 25%–75%, "possibly"; 75%–94%, "likely"; 95%–99%, "very likely"; and >99%, "almost certainly". When the 95% CI simultaneously crossed positive and negative smallest important ES values, the effect was considered "unclear". Statistical analyses were performed using R Studio (R Foundation for Statistical Computing, Vienna, Austria).

Results

The results from the power calculation indicated power = 1.00. Due to the nature of the research question and longevity of data collection (approximately five months), the same athlete was present in both NAM and AM groups and there was missing data; therefore, the assumption of independence and non-missing data was violated and a linear mixed model was used for the analysis. The average bedtime was 11:41 p.m. on NAM and 10:57 p.m. on AM. The average wake time was 7:21 a.m. on NAM and 6:20 a.m. on AM.

Regarding the primary research question, we failed to reject the null hypothesis. On AM days, athletes slept for a shorter overall duration, perceived that their overall quality of sleep was reduced, and perceived it was more difficult to fall asleep and awaken compared to NAM days (Table 1). Specifically, it appears that one athlete reported higher sleep duration on nights prior to early morning training (Figure 1a). Additionally, one athlete appears to have a much higher sleep latency, regardless of training time, compared to other athletes (Figure 1b). The range of reported awakenings throughout the night varies between athlete, with some athletes reporting as few as zero awakenings and others reporting as many as 10 awakenings, regardless of training time (Figure 1c). One athlete reported much greater difficulty falling asleep and poor sleep quality on both AM and NAM nights than the other athletes (Figures 2a and 2b). There was high variability between athletes in response to the feeling of refresh upon waking and the ease of awakening (Figures 2c and 2d).

Table 1. Differences in Sleep Variables Between Nights That Do not Precede Early Morning Training (NAM) and Nights Preceding Early Morning Training (AM)

	NAM		AM						
Metric	***M***	***SD***	***M***	***SD***	***F*-value**	**Degrees of Freedom**	**[95% CI]**	***p*-value**	**Interpretation**
Sleep Duration (hours)	8.26	1.43	7.97	1.09	9.75	10	[0.08, 0.36]	$p < .001$*	Possibly ↓
Sleep Latency (minutes)	14.91	16.39	18.52	18.78	2.47	9	[–0.05, 0.49]	$p = .12$	Possibly ↑
Sleep Quality (AU)	3.30	1.01	3.02	1.06	2.46	9	[0.07, 0.48]	$p < .001$*	Likely↓
Refreshness (AU)	2.79	0.99	2.62	0.97	2.59	9	[–0.04, 0.38]	$p = .11$	Possibly Trivial
Dream (AU)	2.57	1.11	2.43	1.22	1.08	9	[–0.11, 0.36]	$p = .30$	Possibly Trivial
Wake Episodes (Count)	4.31	1.01	5.13	0.93	0.67	9	[–0.30, 0.72]	$p = .41$	Unclear
Ease of Falling Asleep (AU)	3.24	1.08	2.88	1.11	7.34	9	[0.39, 1.18]	$p < .01$*	Most Likely ↓
Ease of Awakening (AU)	2.81	1.01	2.52	0.93	11.56	8	[0.08, 0.51]	$p < .01$*	Likely↓

AU = arbitrary units from the 1-5 Likert Scale questions on the Karolinska Sleep Diary. *Indicates statistical difference between NAM and AM ($p < 0.05$). Early morning training was defined as any day in which a training session was recorded before 8:00 a.m.

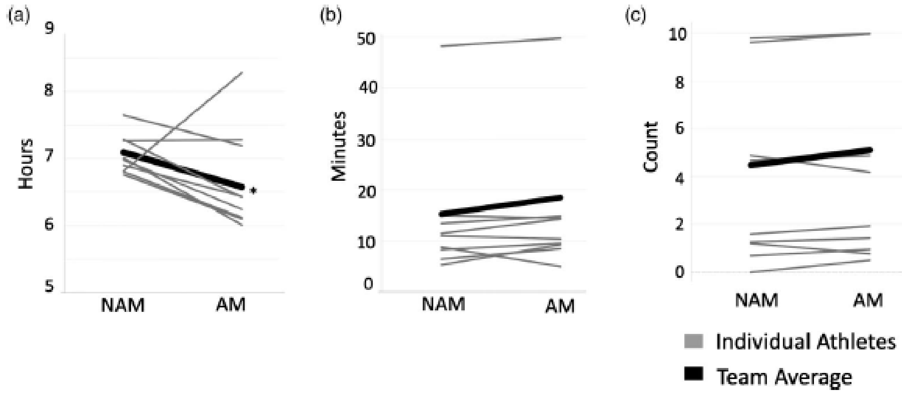

Figure 1. Differences in a) sleep duration, b) sleep latency, c) number of awakenings between nights that do not precede early morning training (NAM) and nights preceding early morning training (AM). Early morning training was defined as any day in which a training session was recorded before 8:00 a.m.

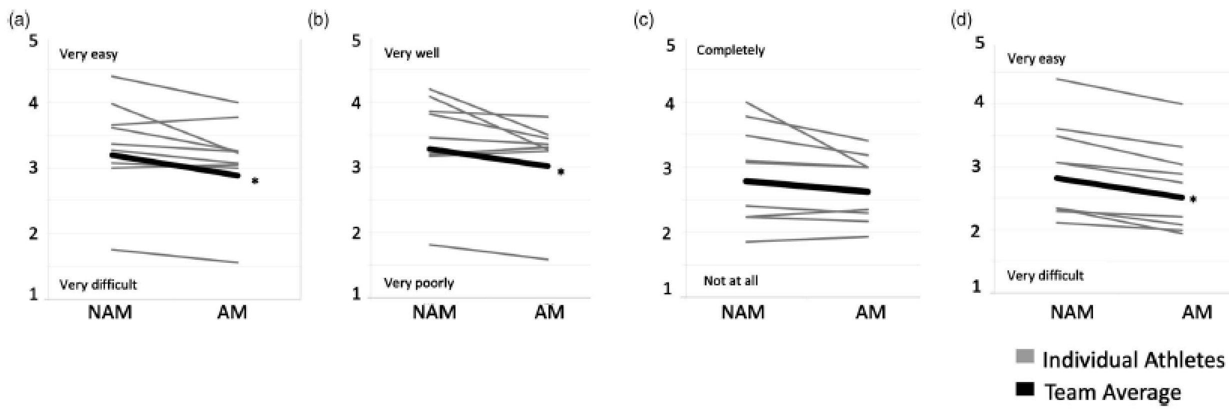

Figure 2. Differences in a) ease of falling asleep, b) sleep quality, c) feeling of refresh, and d) ease of awakening between nights that do not precede early morning training (NAM) and nights preceding early morning training (AM). Early morning training was defined as any day in which a training session was recorded before 8:00 a.m.

Discussion

This is the first study to observe the sleeping behaviors of NCAA DI female cross-country runners throughout an entire competitive season. While some research has examined sleep characteristics of female athletes, no study has explicitly evaluated the sleep of a collegiate female cross-country team in relation to training times (Mah et al., 2018). The findings of the current study show that these athletes obtained the recommended 7 hours of sleep per night in both groups; however, sleep duration was lower on AM than NAM. Sleep quality, ease of falling asleep, and ease of awakening are worse with early morning training sessions when compared to days without a morning session. Similarly to the findings of the current study, Sargent et al. demonstrated that early morning training negatively impacted sleep quantity by 1.7 hours in elite swimmers when compared to rest days (Sargent, Halson, et al., 2014).

From a broader perspective of overall sleep health, collegiate athletes across all sports have been classified as poor sleepers and, on average, obtained approximately 7 hours of sleep on weekdays; however, of the 15 different female sports observed in this study, the average sleep duration was >7 hours for nine of the sports (Mah et al., 2018). The findings from the current study demonstrated that training start time was a factor related to total sleep time, as athletes obtained an average of 8.26 hours of sleep on NAM and 7.97 hours on AM. Even though training start time affected sleep duration, the athletes in the present study obtained the recommended 7 hours of sleep. Despite obtaining the recommended sleep quantity on NAM and AM, sleep quality, ease of falling asleep, and ease of awakening was affected by early morning training.

There are several reasons for the observed differences in sleep metrics on nights prior to early morning training. It is possible that an earlier wake time contributed to a reduction in sleep duration on nights prior to early morning training. Previous literature reported that bedtimes and wake times were later prior to rest days when compared to nights prior to training days, which resulted in athletes obtaining more sleep (Sargent, Halson, et al., 2014). These particular athletes also had other demands, including academic and social, which may prevent them from focusing primarily on their sport.

On nights prior to early morning training, the athletes in the present study experienced greater difficulty falling asleep when compared to all other nights. One hypothesis for this finding is based on previous literature which points to increased levels of stress and anxiety related to falling asleep (Lindberg et al., 1997). The athletes in the present study may be experiencing anxiety due to stress related to academic, social, and sport-specific factors (Etzel, 2006). Previous research has also pointed to the 'forbidden zone,' in which individuals who go to bed earlier than usual have difficulties falling asleep (Lavie, 1986). The athletes in the current study reported a bedtime approximately 45 minutes earlier on nights prior to an early morning training when compared to all other nights. The sleep quality rating was decreased on AM, which is similar to previous research that found decreases in sleep quality on training days when compared to rest days (Kölling et al., 2016). Athletes were getting less total sleep time, which could be related to the ease of awakening being rated as more difficult on AM when compared to NAM.

In addition to mean differences between AM and NAM, the variety of individual responses in sleeping behaviors are evident in Figures 1 and 2. Outliers can also be seen in Figure 1 in regard to sleep duration and sleep latency. Ease of falling asleep, sleep quality, and ease of awakening also demonstrate individual responses between groups. Further investigation is warranted to determine potential explanations for these individual responses.

There is a growing body of literature examining the implications for decrements in sleep quantity, structure, consistency, and quality on performance and health, as well as how elite sport affects sleep (Leeder et al., 2012; Schaal et al., 2015, 2011; Souissi et al., 2008). Mougin et al. found that sleep disturbances were related to an increase in heart rate, minute ventilation, and plasma lactate concentration during submaximal and maximal exercise (Mougin et al., 1991). Mood and cognitive performance related to alertness, reaction time, memory, and decision making have been thoroughly investigated in regards to athletic performance and the general consensus is that decreased sleep quality, as seen on night's prior to early morning training in the present study, is associated with negative outcomes (Antunes et al., 2017; Brandt et al., 2017; Gupta et al., 2017). Additionally, lower perceived sleep quality has been associated with poor academic outcomes in the university setting (Gilbert & Weaver, 2010).

In a recent review surrounding sleep interventions in athletes, Bonnar et al. reported that sleep extension appeared to improve exercise performance (Bonnar, Bartel, Kakoschke, & Lang, 2018). Although exercise performance was not measured in this particular investigation, our finding suggests coaches and sports medicine professionals should consider limiting the number of early morning training sessions as this may help improve the sleep quantity and quality of NCAA DI women's cross-country athletes. It is well-established that there are sex differences in sleep characteristics, including higher sleep latency, higher reports of sleepiness, and an increased risk of insomnia in females (Ohayon et al., 2013; Zhang & Wing, 2006). Since the participants in the current study are female student-athletes, further consideration should be made surrounding sleep enhancement strategies, including schedule considerations, not only for an enhancement in sport performance, but also for potential improvement in academic success, overall player wellness, and life after sports. Sport practitioners should also consider individual monitoring to determine if particular student-athletes need specific interventions to improve their sleep quantity, quality, and consistency.

The current study is not without limitations. Firstly, sleep measures were assessed using a subjective sleep survey. Although validated, the results are dependent on the athletes answering the survey appropriately (Åkerstedt et al., 1994). A recent study examined the differences between subjective and objective sleep measures in professional rugby players and their findings supported the use of subjective sleep measures (Caia et al., 2018). The authors stated that coaches and scientists should consider that sleep duration was over-estimated with the subjective measure by about 19.8 minutes when compared to the objective measure (Caia et al., 2018). Another limitation to this study is that the survey could have been completed at any time of day, which could have affected the reliability of the results. Future studies should look to improve upon these methods by only allowing athletes to answer the survey immediately upon wakening. Additionally, only nights of sleep prior to early morning training were included in the AM group. Other early morning events (i.e., class, meetings, appointments) were not accounted for in this data set and were included in the NAM group. Despite the inclusion of these alternative early morning events in the NAM group, several measures of sleep quality and quantity were impacted by early morning training, indicating that the early morning training could have been one of the main factors in sleep decrements observed in this investigation. Nights of sleep prior to competition and rest days were also included in the NAM group, which could also have affected these results. Future research studies should look to examine how early morning training, competition, and rest days impacted sleep.

Conclusions

This study was the first to investigate the sleeping patterns of an NCAA Division I female cross-country team throughout the duration of an entire competitive season. This study demonstrated that early morning training was associated with lower sleep duration, sleep quality, ease of falling asleep, and ease of awakening. Regardless of lower sleep duration on nights prior to early morning training, the athletes in this study obtained the recommended 7 hours of sleep per night.

Because there are known sex differences in several sleep variables, this study will provide insight into the unique sleep characteristics of female cross-country athletes (Mallampalli & Carter, 2014). Research related to sleep and sport performance outcomes (i.e., race times), cognitive performance, mood, and academic success, especially in the student-athlete population, is warranted. Additionally, future research should look to investigate potential reasons for outliers in sleeping behavior (sleep disorders, sleep medication, mental health disorders) and determine if tailored interventions would improve sleep, performance, and wellness outcomes.

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